Fang LI, Jia SHENG, San-yuan ZHANG,2017. Laplacian sparse dictionary learning for image classification based on sparse representation. *Frontiers of Information Technology & Electronic Engineering*, **18**(11):1795-1805.
https://doi.org/10.1631/FITEE.1600039

Laplacian sparse dictionary learning for image classification based on sparse representation

Key words: Sparse representation; Laplacian regularizer; Dictionary learning; Double sparsity; Manifold

Corresponding author: San-yuan ZHANG
E-mail: syzhang@zju.edu.cn
ORCID: http://orcid.org/0000-0001-8604-874X

Motivation

1. Dictionary learning plays an important role in the minimization of the reconstruction error between the original signal and its sparse representation in the space of the learned dictionary. Although using training samples directly as dictionary bases can achieve good performance, the main drawback of this method is that it may result in a very large and inefficient dictionary due to noisy training instances.
2. To obtain a smaller and more representative dictionary from training data.

Main idea

1. Sparse dictionaries are efficient for large dictionaries and high-dimensional signals, show much more stable perfor-mance and lead to higher compression rates.
2. High dimensional images may reside on a lower dimensional subspace or sub-manifold. An efficient subspace learning algorithm should be able to discover manifold structure of the image space.

Method

1. According to the smoothness assumption, if data points are close to each other, then their coefficients should be close as well. To preserve locality information for the sub-dictionary, in our method, we incorporate the Laplacian regularizer into the dictionary learning process.
2. We focus on a new over-complete dictionary learning method in which the ℓ_1 -norm sparsity is imposed not only on the coefficients but also on the dictionary atom.

Object function

By incorporating the Laplacian regularizer into the original sparse coding and imposing the -norm sparsity on the dictionary, our objective function can be written as: ℓ_1

$$J_{D,S} = \arg \min_{D,S} \{ \|X - DS\|_F^2 + \lambda \sum_i \|s_i\|_1 + \beta \sum_j \|d_j\|_1$$

$$+ \gamma Tr(SLS^T) \} \quad \text{s.t. } d_j^T d_j = 1, \forall j$$

Major results

The top recognition rates (%) of different methods on test databases				
Method	E-Yale B	ORL	AR	i-LIDS-MA
KNN	92.46%	94.37%	88.14%	53.42%
SRC	97.09%	95.00%	91.14%	55.87%
MFL	97.62%	96.25%	91.86%	57.17%
GSC	98.51%	97.50%	93.71%	58.11%
LSD	99.42%	98.75%	94.57%	59.03%

Conclusions

The proposed Laplacian sparse dictionary has a sparse structure and can preserve the local structure of the data space. Embedding LSD into a sparse representation based classifier can improve the performance of SRC based image classification. Our experiments on the Extended Yale B, ORL, and AR face image databases and the i-LIDS-MA person image dataset demonstrated that the proposed LSD algorithm has higher accuracy and stable performance.